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L-04-158

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: Beaver Valley Power Station, Unit No. 1
BV-1 Docket No. 50-334, License No. DPR-66
Reactor Head Inspection 60-Day Report for 1R16

Reference:
1) First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors, dated February 20, 2004

During the recent Beaver Valley Power Station (BVPS) Unit 1 1R16 Refueling Outage, inspections of the reactor pressure vessel (RPV) head and associated penetration nozzles were performed. In accordance with NRC Order EA-03-009 (Reference 1) Section IV.E, the 60-day report, detailing the inspection results is being provided. The BVPS Unit 1 Evaluation Report for 1R16 RPV Penetration Inspections is enclosed with this letter.

There are no new regulatory commitments contained in this letter. If there are any questions concerning this matter, please contact Mr. Larry R. Freeland, Manager, Regulatory Compliance at 724-682-4284.

Sincerely,

L. W. Pearce

L. William Pearce

Enclosure

c: Mr. T. G. Colburn, NRR Senior Project Manager
Mr. P. C. Cataldo, NRC Sr. Resident Inspector
Mr. S. J. Collins, NRC Region I Administrator

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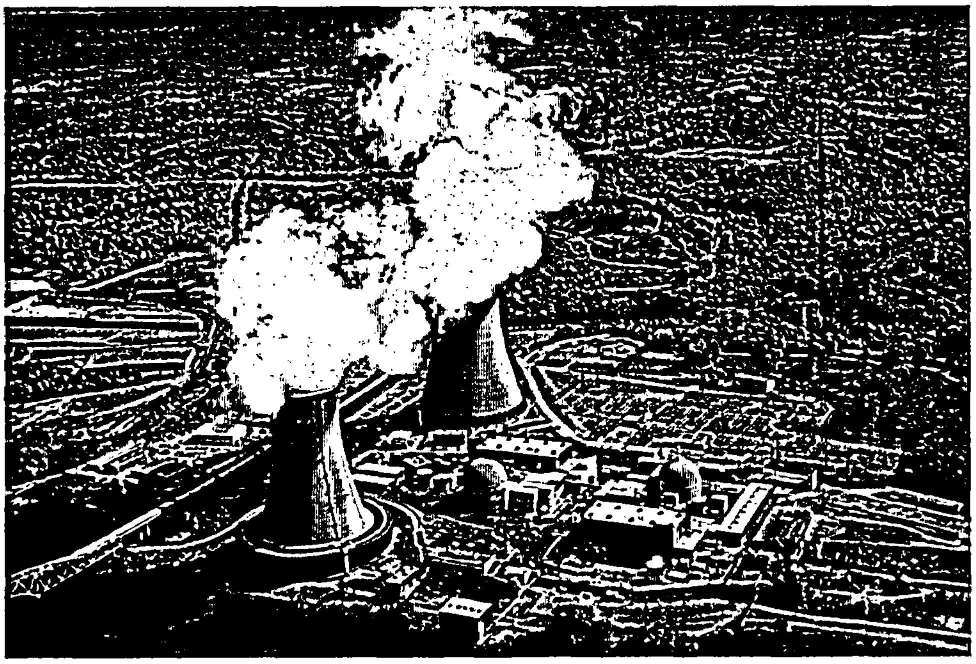


Evaluation Report for

1R16

Beaver Valley Unit 1

Reactor Vessel Head Penetration

Inspections

(Ref: Order EA-03-009)

December 2004

Introduction

Reactor Pressure Vessel (RPV) Head Inspections were performed at Beaver Valley Power Station (BVPS) Unit 1 during the 1R16 Refueling Outage in accordance with the First Revised NRC Order EA-03-009. The Order establishes criteria by which licensees must perform periodic inspections of the reactor vessel head. FirstEnergy Nuclear Operating Company (FENOC) provided a response to the Order for BVPS via letter L-04-030, dated March 5, 2004.

RPV Head Configuration

The BVPS Unit 1 RPV contains sixty-five (65) Alloy 600 penetration tubes that are interference fit in the reactor vessel head and attached with Alloy 182/82 partial penetration J-groove welds. The head also contains one Alloy 600 vent line that is clearance fit in the reactor vessel head and attached with an Alloy 182/82 partial penetration J-groove weld.

The 65 Control Rod Drive Mechanism (CRDM) penetration tubes measure 4.0" on the outside diameter (OD) and have an inside diameter (ID) dimension of 2.75". The wall thickness is 0.625". The RPV head vent line has a nominal OD dimension of 1.0" and a nominal ID dimension of 0.770". (NOTE: The bottom of the RPV head vent line is flush with the attachment weld and inner head surface, thus, no OD wetted surface exists.)

Susceptibility Ranking

The cumulative Effective Degradation Years (EDY) of the BVPS Unit 1 reactor head were calculated at the conclusion of Cycle 16 in accordance with Paragraph IV.A of the Order. The Unit 1 RPV head has maintained one consistent bulk head temperature of 595°F for its operating history, as reported in Table 2-1 of EPRI MRP-48 and validated by a BVPS/Westinghouse study using external thermocouple measurements obtained from the BVPS Unit 1 RPV head surface during Cycle 16. The cumulative EFPY for the Unit 1 RPV head through Cycle 16 was calculated to be 18.38. These plant-specific inputs were used to calculate EDY_{1R16} per the equation provided in Paragraph IV.A of the Order:

$$EDY_{1R16} = \sum_{j=1}^{n} \left\{ \Delta EFPY_j \exp\left[-\frac{Q_i}{R} \left(\frac{1}{T_{head,j}} - \frac{1}{T_{ref}} \right) \right] \right\}$$

$$EDY_{1R16} = \sum_{j=1}^{1} \left\{ (18.38 years) \exp\left[-\frac{(50 kcal/mole)}{(1.103x10^{-3} kcal/mole°R)} \left(\frac{1}{(1054.67°R)} - \frac{1}{(1059.67°R)} \right) \right] \right\}$$

$$EDY_{1R16} = 15.01$$

The calculated EDY of 15.01 and the previously identified cracking in four (4) RPV head penetrations during the 1R15 refuel outage places the BVPS Unit 1 RPV Head in "High" susceptibility per the table in Paragraph IV.B of the Order.

Required Inspections

As a "High" susceptibility plant, the inspection requirements of Paragraph IV.C.(1) of the Order apply to the BVPS Unit 1 RPV head. The inspections requirements of Paragraph IV.C.(1) were met during the BVPS 1R16 refuel outage by the successful completion of RPV head inspections in accordance with the requirements detailed in Paragraphs IV.C.(5)(a) and IV.C.(5)(b) and Paragraph IV.C.(1), Footnote 3 of the Order.

Specifically, a visual inspection of the RPV head was performed, including bare metal visual examination of the RPV head surface and 360° around each RPV head penetration, in accordance with Paragraph IV.C.(5)(a) of the Order. Remote visual examinations were performed by Westinghouse/R. Brooks Associates and Wesdyne/FENOC VT-2 qualified personnel.

Underhead NDE examinations were performed using a combination of ultrasonic and eddy current examination techniques, in accordance with the requirements of Paragraph IV.C.(5)(b)(iii). Multiple techniques had to be used in order to account for difficult penetration geometries and access limitations. (Note: Each RPV head penetration was inspected using ultrasonic OR eddy current testing. Examination techniques were not combined on any one penetration, therefore, the requirements of Paragraphs IV.C.(5)(b)(iii)(1) and (2) do not apply.) In all cases (ultrasonic or eddy current), the minimum examination coverage extended from 2 inches above the highest point of the root of the J-groove weld to 1 inch below the lowest point at the toe of the J-groove weld. For BVPS Unit 1, the minimum required coverage below the toe of the J-groove weld is 1 inch, as a plant-specific stress analysis has been performed (WCAP-16071), and tensile stresses beyond 1 inch below the J-groove weld are shown to be < 20 ksi in all cases, as shown in Attachment A.

In addition to the ultrasonic and eddy current examinations performed, Footnote 3 of Paragraph IV.C.(1) of the Order requires that RPV head penetration nozzles or J-groove welds repaired using a weld overlay must be examined by either ultrasonic, eddy current, or dye penetrant testing. During the previous 1R15 refuel outage, weld overlays were applied to the tube OD and J-groove weld of four (4) penetrations (50, 51, 52, and 53) identified as having relevant OD-initiated indications in the tube material below the J-groove weld. During the 1R16 inspections, dye penetrant testing was performed on these weld overlay repairs as required by Footnote 3.

A summary of the volumetric and surface examinations performed on each RPV head penetration is provided in Attachment B.

All of the nondestructive examinations performed during 1R16 were conducted in accordance with site-specific field service procedures. All CRDM ultrasonic and eddy current examination techniques have been demonstrated through the Electric Power Research Institute / Materials Reliability Program (EPRI/MRP) protocol. In the absence of an EPRI/MRP protocol for the vent line applications, the examination procedures and techniques were demonstrated as identified in Westinghouse Technical Justifications WDI-TJ-011-03 and WDI-TJ-044-04. Dye penetrant examinations were conducted using Westinghouse and FENOC dye penetrant examination procedures and ASME III acceptance criteria.

Inspection Results

Visual Inspections (Paragraph IV.C.(5)(a))

VT-2 visual inspection of 360° around each of the 65 CRDM penetrations and the vent line showed no indication of penetration leakage characteristic of a through-wall leak. The carbon steel assessment performed on 100% of the RPV head carbon steel base metal inside the ventilation shroud found no new degraded conditions on the RPV head surface.

Minor corrosion (< 1/8" in depth) of the RPV head base metal was observed around CRDM Penetrations 53 and 65. This condition was previously observed during visual inspections in outages 1R14, 1MO2, and 1R15. The leakage that caused the degradation was previously determined to have originated at the adjacent canopy seal (Penetration #53) above the RPV head mirror insulation. The conditions of Penetrations 53 and 65 observed during the 1R16 refueling outage were compared with the previously documented conditions, and no change in the condition of the RPV head base metal around these penetrations was observed.

Ultrasonic Examinations (Paragraph IV.C.(5)(b)(i))

Ultrasonic examination with leak-path detection capability was performed on twenty-eight (28) CRDM penetrations in accordance with Paragraph IV.C.(5)(b)(i) of the Order. These examinations were performed using the Westinghouse 7010 Open-housing Scanner (7) or Gapscanner Trinity Probes (21). Each examination technique simultaneously performs Time-of-Flight-Diffraction (TOFD) ultrasonic testing for the detection of axial or circumferential degradation in the tube material, 0° ultrasonic testing to identify potential leak paths, and eddy current surface examinations (supplemental to Paragraph IV.C.(5)(b)(i) requirements).

No detectable degradation characteristic of Primary Water Stress Corrosion Cracking (PWSCC) was reported in twenty-four (24) of the twenty-eight (28) penetrations inspected with UT. Examinations of the remaining four (4) penetrations repaired by weld overlay in 1R15 (Penetrations 50 – 53) indicated no change in conditions. Analysis of the TOFD ultrasonic data showed no changes in the dimensions of the overlayed defects, and no new defects were identified.

No leak-paths were identified in any of the twenty-eight (28) penetrations inspected using 0° ultrasonic testing.

Supplementary eddy current testing of the twenty-eight (28) penetrations inspected ultrasonically showed evidence of craze cracking on the ID of eight (8) penetration tubes (8, 9, 12, 47, 49, 51, 52, and 53). All were confirmed to be pre-existing cases through comparison to examination data from the previous inspection in 1R15. None of the craze cracking was visible in the TOFD UT data, indicating the indications to be < ~0.040" in depth.

The extent of ultrasonic examination coverage was verified for each penetration by confirming that 1) tube entry signals were evident in the eddy current and ultrasonic data, and that 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld. In all cases, examination coverage included at least 1.0" below the lowest elevation of the J-groove weld.

Eddy Current Examinations (Paragraph IV.C.(5)(b)(ii))

The remaining thirty-seven (37) CRDM penetrations not inspected ultrasonically, as well as the head vent line and weld, were inspected using eddy current testing in accordance with Paragraph IV.C.(5)(b)(ii) of the Order. The ID of each CRDM penetration was inspected using the Westinghouse Eddy Current Gapscanner. The OD and J-groove weld of each CRDM penetration was inspected using the Grooveman eddy current end effector. The head vent tube eddy current inspection was performed using an array of 16 plus-Point probes and a low frequency bobbin coil. The head vent weld eddy current examination was performed with an array of 28 plus-Point coils.

No detectable degradation characteristic of PWSCC was reported in any of the thirty-seven (37) CRDM penetration J-groove welds or penetration tube OD and ID surfaces examined using the eddy current gapscanner or Grooveman end effector. Evidence of craze cracking was identified on the ID surface of one penetration tube (36). This condition was confirmed by historical (1R15) data with no apparent increase in size or extent. Eddy current examinations of the head vent tube and weld identified no detectable degradation characteristic of PWSCC.

The extent of ID eddy current examination coverage was verified for each penetration by confirming that 1) tube entry signals were evident in the eddy current data, and 2) scan coverage elevations were in excess of 2.0" above the uppermost elevation of each weld. In all cases, examination coverage included at least 1.0" below the lowest elevation of the J-groove weld (height determined using OD eddy current data). Penetration OD eddy current examination coverage extended from the bottom of each tube onto the weld fillet around the entire circumference of each tube. J-groove weld eddy current examination coverage extended over the entire weld surface from the weld fillet-tube intersection point to a distance of ~0.5" onto the vessel head cladding.

Dye Penetrant Examinations (Paragraph IV.C.(1), Footnote 3)

During 1R15 (Spring 2003), four CRDM penetrations (50, 51, 52, and 53) were identified with relevant indications requiring repair. All of the indications were OD-initiated and located in the penetration material below the J-groove weld. None of the eddy current or ultrasonic examination data indicated extension of any flaw into the weld material. The four penetrations were repaired using a weld overlay (WOL) technique, specifically, a 2-layer Alloy 52 WOL was applied to each penetration OD and a 3-layer WOL was applied to each J-groove weld. The repairs were performed per Relief Request BV3-RV-04 (approved by NRC letter dated May 14, 2003).

The 1R15 post-repair examinations included dye penetrant testing of the Alloy 52 as-welded surface per ASME III acceptance criteria. The final examination identified no linear indications in the overlay material. Relevant but acceptable indications were left in service and documented as follows:

Penetration	Orientation	Type	Size
#50	135°	Rounded	1/8"
#51	20°, 45°	Rounded, Rounded	1/8", 1/8"
#52	20°	Rounded	1/8"
#53	No indications identified		

During 1R16, follow-up dye penetrant examinations were performed on Penetrations 50 – 53 in accordance with the requirements of Paragraph IV.C.(1) of the Order. Examinations were performed in accordance with ASME III acceptance criteria by Westinghouse/FENOC Level II personnel. The final review was conducted by the FENOC Level III reviewer and the onsite ANII.

The initial examinations identified no linear indications in the overlay material. Relevant rounded indications were noted as follows:

Penetration	Orientation	Type	Size
#50	No indications identified		
#51	20°, 45°	Rounded, Rounded	1/8", 1/16"
#52	20°	Rounded	3/16" (UNSAT)
#53	350°	Rounded	3/16" (UNSAT)

The rejectable indications on Penetrations 52 and 53 were documented in the BVPS Corrective Action Program (BV CR 04-08751). Minor flapping in the areas of interest of the overlay surface was performed on Penetrations 52 and 53, with care taken to ensure that the 3rd layer of the overlay remained intact. Re-examination of Penetrations 52 and 53 was performed post-flapping. The re-examinations identified no linear indications, and relevant but acceptable indications as follows:

Penetration	Orientation	Type	Size
#52	20°	Rounded	< 1/8"
#53	350°	Rounded	3/32"

Final disposition of all relevant indications identified during 1R16 was performed within the BVPS Corrective Action Program. Based on the information available and review of the procedures and examination reports, it was concluded that the variance in examination results between 1R15 and 1R16 was likely the result of logging deficiencies and variability in cleaning and inspection techniques, not the growth of existing or initiation of new indications.

All relevant indications left in service following the 1R16 are rounded indications, within ASME III acceptance criteria, and are not characteristic of any known inservice degradation mechanism, including PWSCC.

Inspection Summary

RPV head inspections were completed during 1R16 in accordance with the requirements of the First Revised Order EA-03-009. Visual inspection of the top of the RPV head in accordance with Paragraph IV.C.(5)(a) showed no indication of RPV head penetration leakage or new degradation of the carbon steel surface. Under-head examinations performed in accordance with Paragraph IV.C.(5)(b) identified no new degradation characteristic of PWSCC in any of the RPV head penetration base material or J-groove welds and no indications of leak paths in the interference fit areas. Ultrasonic inspections of previously (1R15) identified and repaired (weld overlay) indications in Penetrations 50 – 53 showed no change in conditions. Finally, dye penetrant examinations of the four weld overlay repairs were performed in accordance with Paragraph IV.C.(1), Footnote 3, and were found acceptable.

ATTACHMENT A

Excerpts from WCAP-16071

Hoop Stress vs. Distance from Bottom of Weld

Curves for Bounding Penetration Geometries

Figure 1
Hoop Stress Vs Distance from Bottom of Weld
0° CRDM Center Penetration Nozzle – Uphill and Downhill

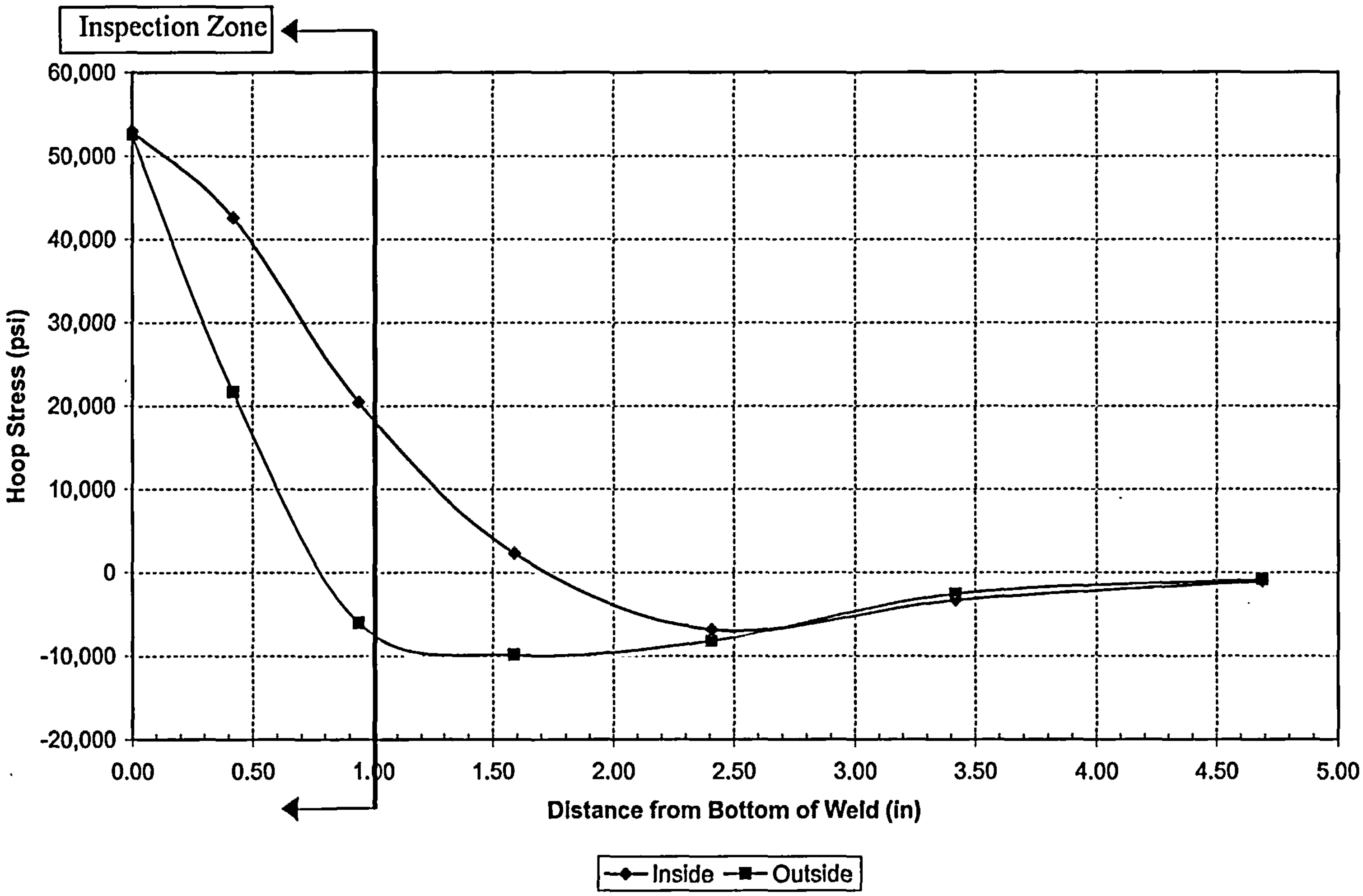


Figure 2
Hoop Stress Vs Distance from Bottom of Weld
28.6° CRDM Center Penetration Nozzle – Downhill

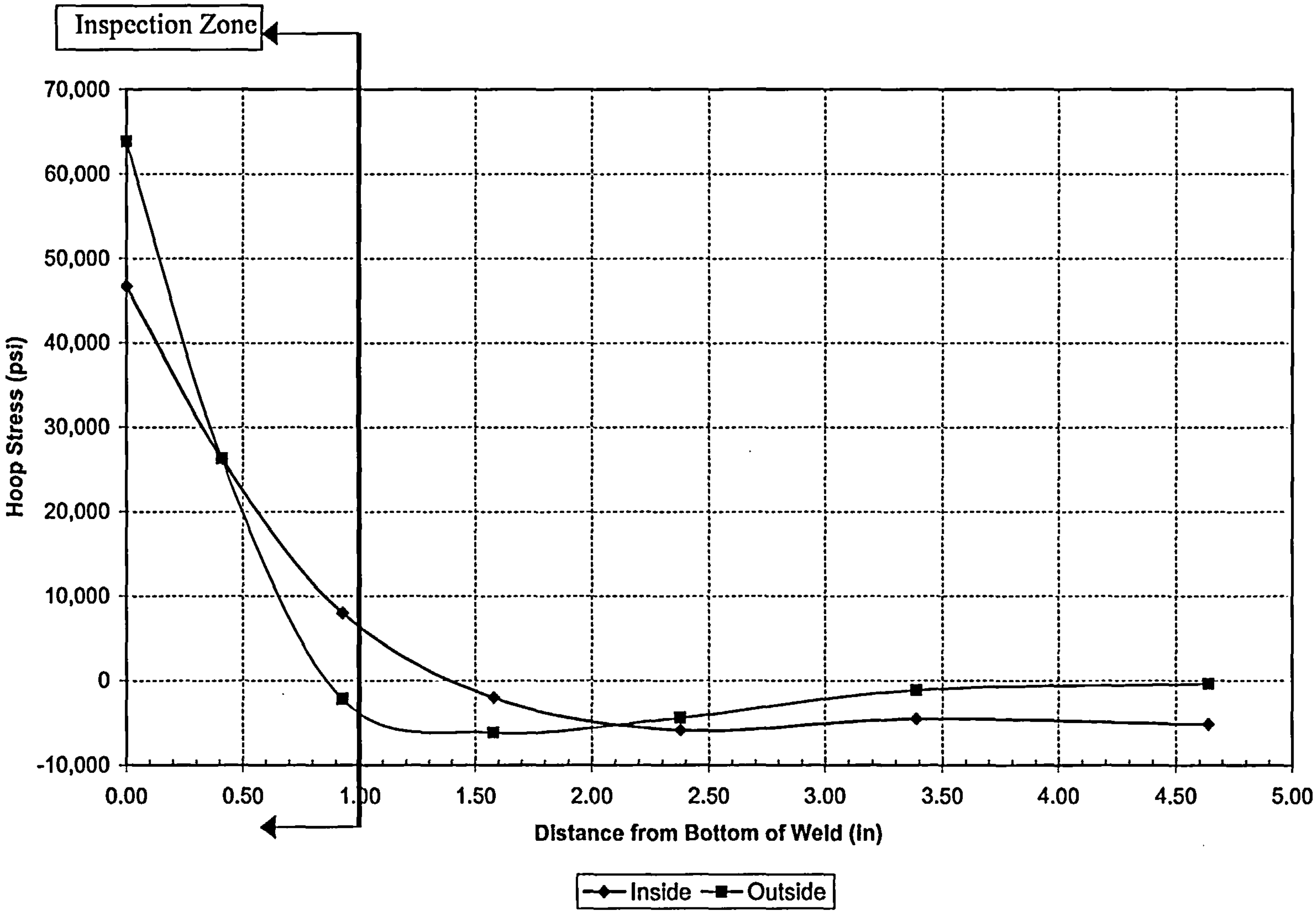


Figure 3

Hoop Stress Vs Distance from Bottom of Weld

28.6° CRDM Center Penetration Nozzle – Uphill

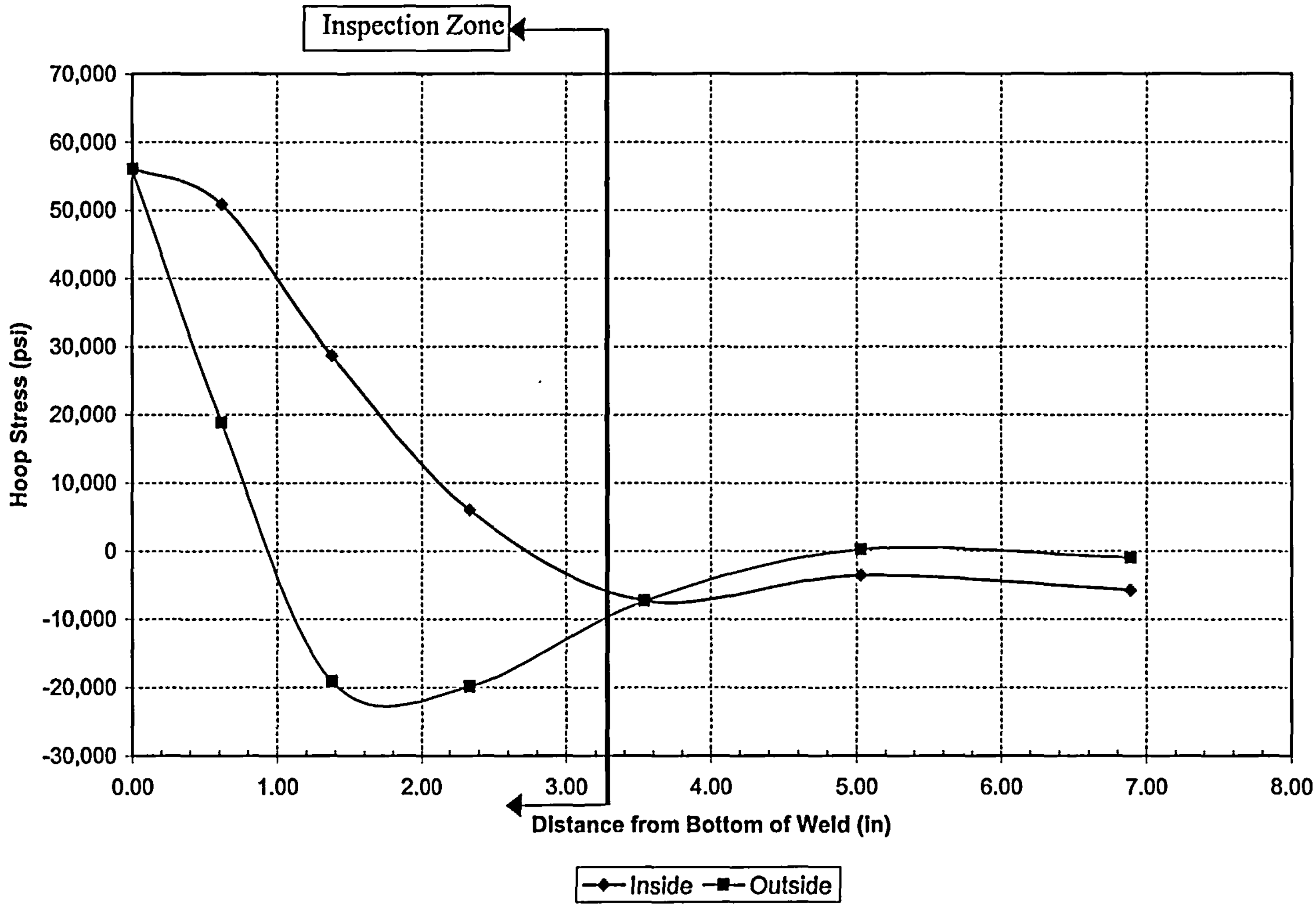


Figure 4
Hoop Stress Vs Distance from Bottom of Weld
38.6° CRDM Center Penetration Nozzle –Downhill

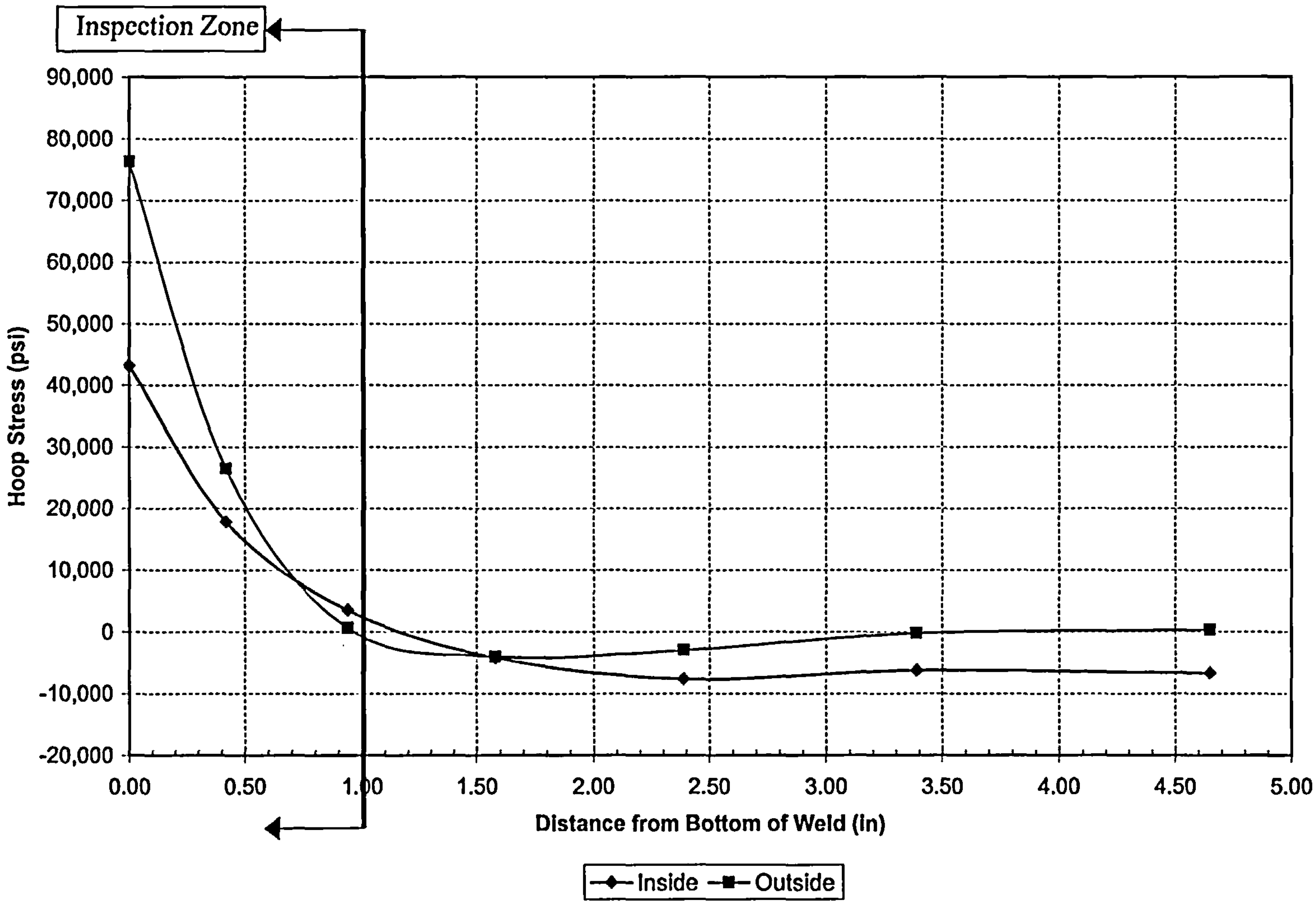


Figure 5
Hoop Stress Vs Distance from Bottom of Weld
38.6° CRDM Center Penetration Nozzle –Uphill

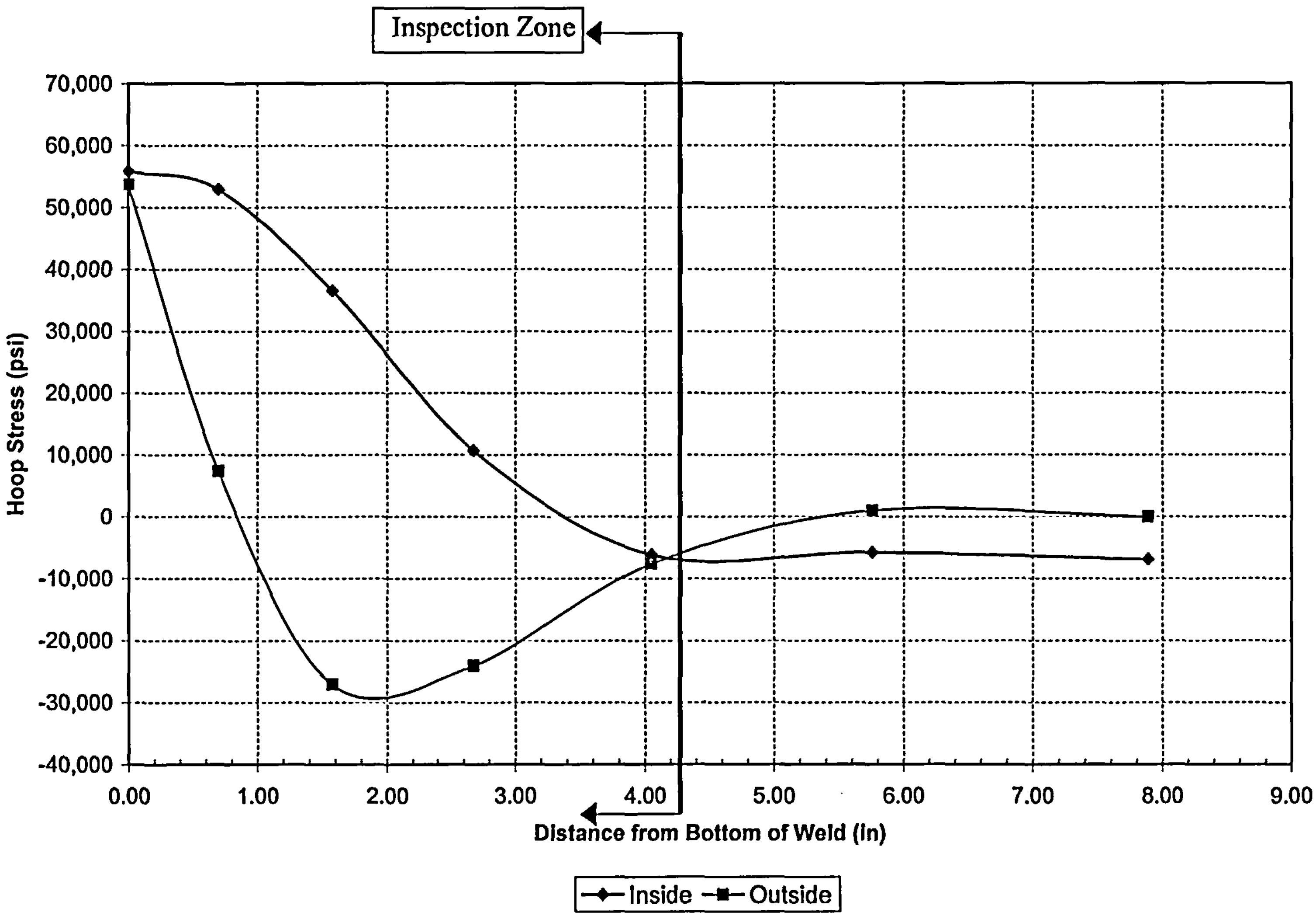


Figure 6
Hoop Stress Vs Distance from Bottom of Weld
40.0° CRDM Center Penetration Nozzle –Downhill

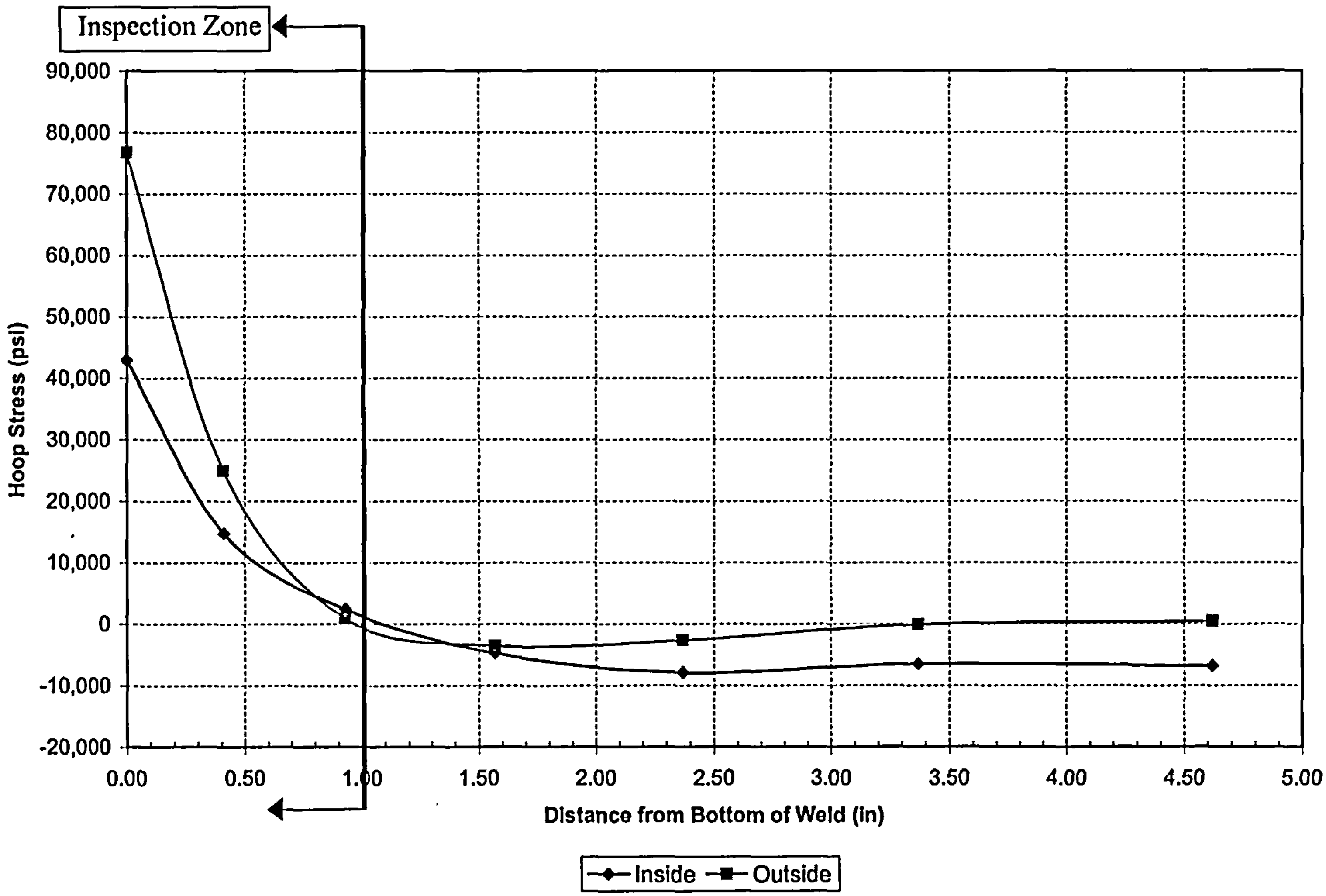


Figure 7
Hoop Stress Vs Distance from Bottom of Weld
40.0° CRDM Center Penetration Nozzle –Uphill

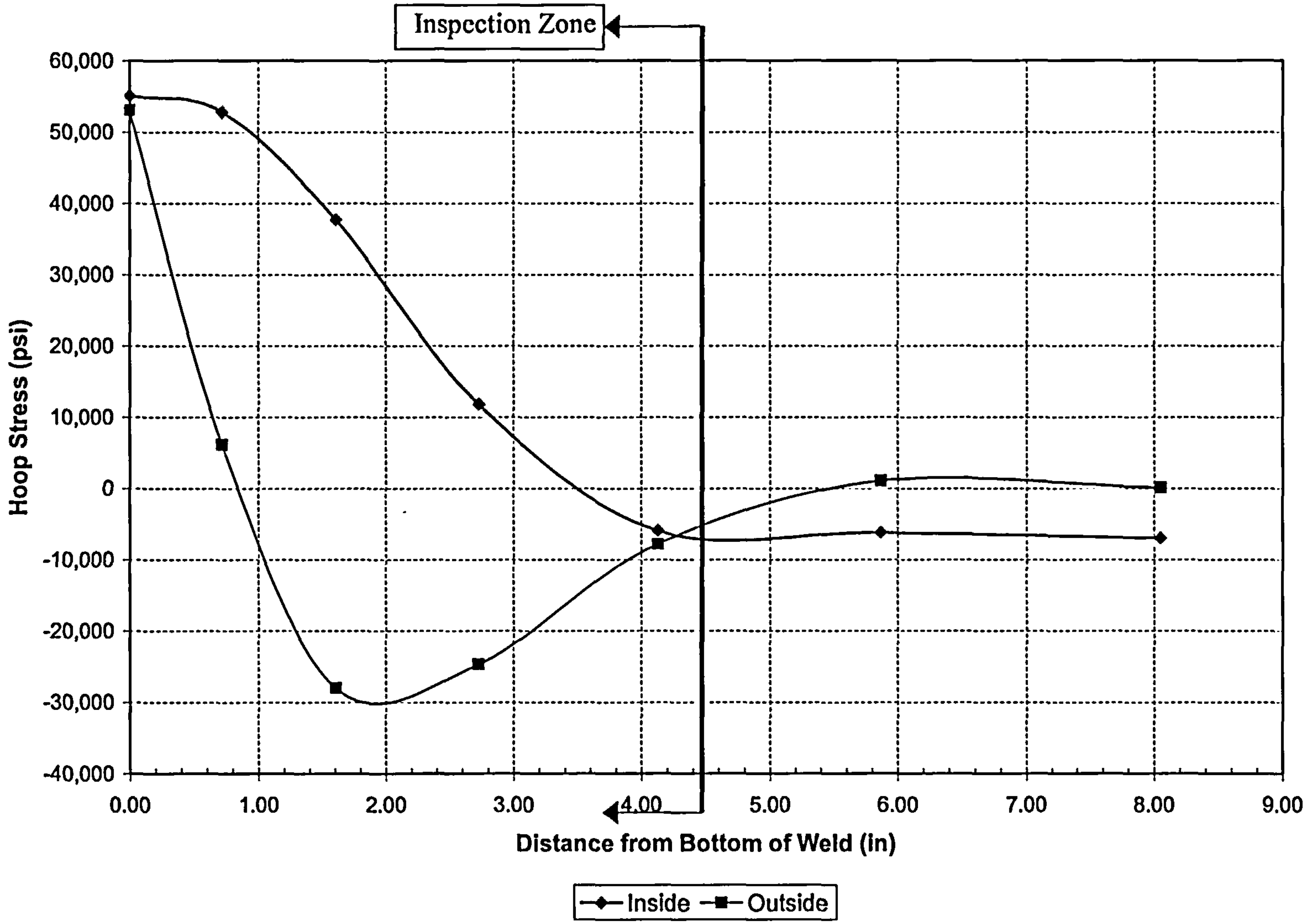


Figure 8
Hoop Stress Vs Distance from Bottom of Weld
42.6° CRDM Center Penetration Nozzle –Downhill

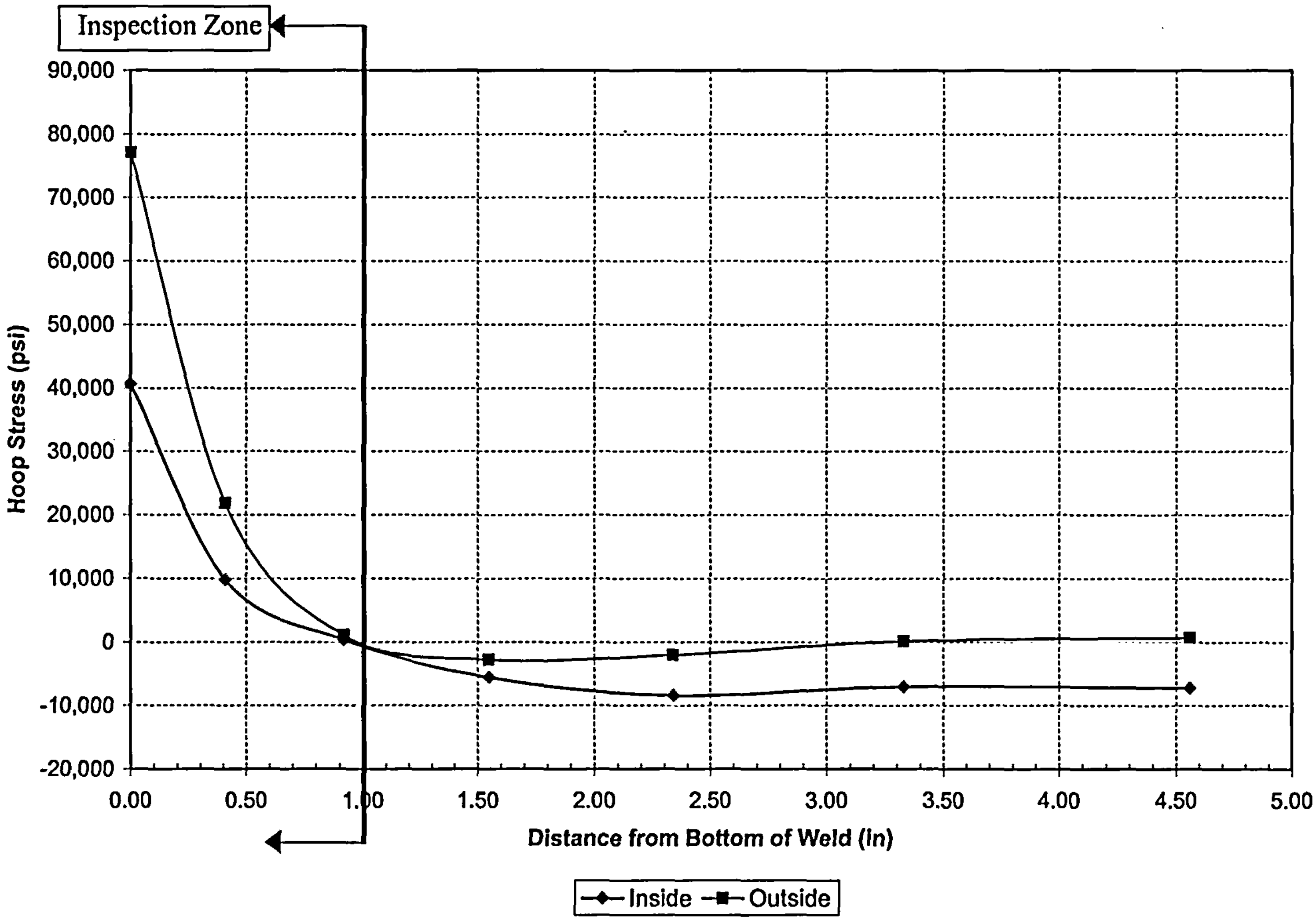
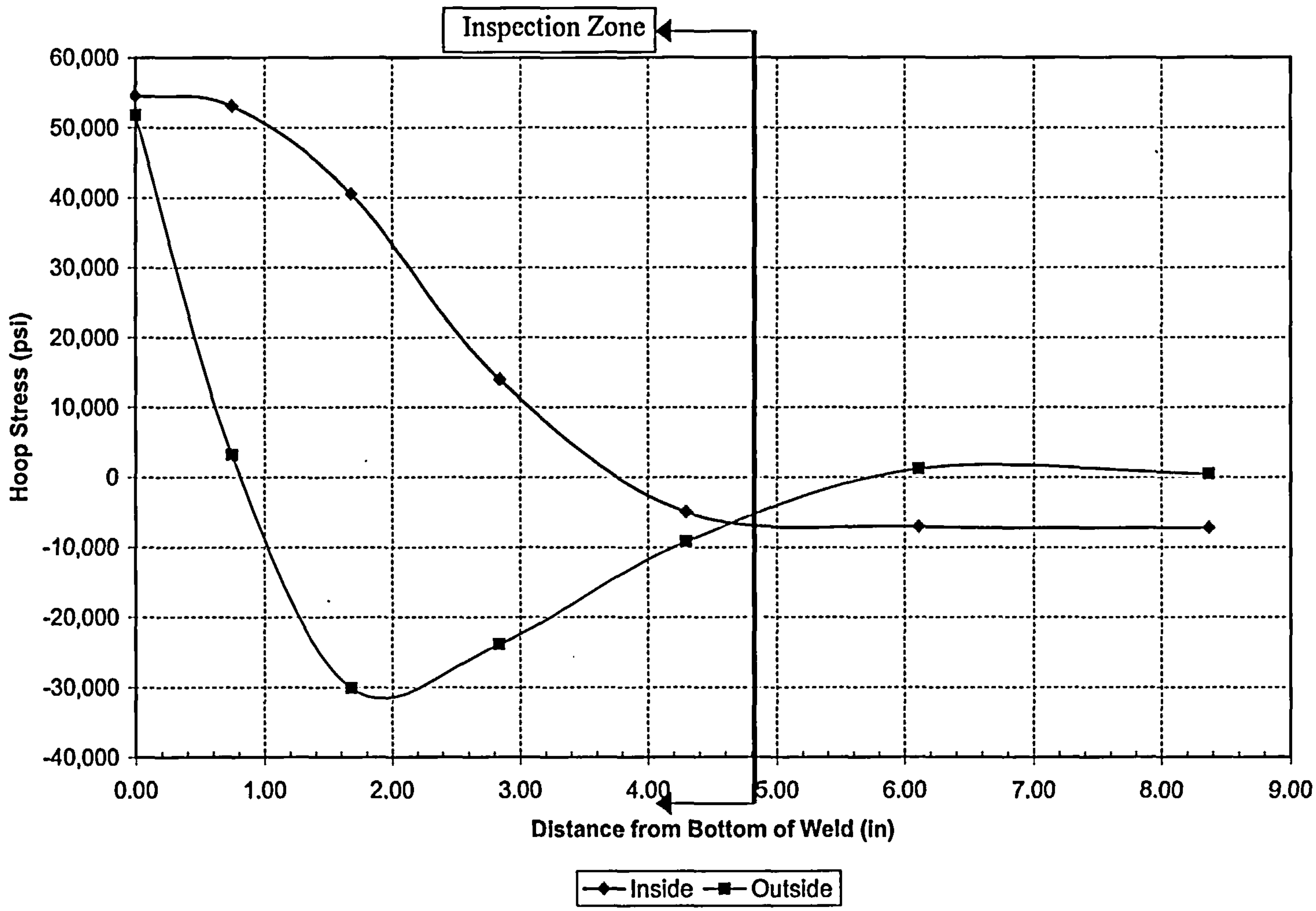


Figure 9
Hoop Stress Vs Distance from Bottom of Weld
42.6° CRDM Center Penetration Nozzle –Uphill



ATTACHMENT B

BVPS 1R16 RPV Head Inspections

Examinations Completed by Penetration

BVPS 1R16 RPV Head Inspections
Examinations Completed by Penetration

Pen. #	TOFD UT	0° UT	ID ECT	OD ECT	J-Weld ECT	WOL PT
1	X	X	X			
2	X	X	X			
3	X	X	X			
4	X	X	X			
5	X	X	X			
6	X	X	X			
7	X	X	X			
8	X	X	X			
9	X	X	X			
10	X	X	X			
11	X	X	X			
12	X	X	X			
13	X	X	X			
14			X	X	X	
15	X	X	X			
16	X	X	X			
17	X	X	X			
18	X	X	X			
19	X	X	X			
20	X	X	X			
21	X	X	X			
22			X	X	X	
23	X	X	X			
24	X	X	X			
25			X	X	X	
26			X	X	X	
27			X	X	X	
28			X	X	X	
29			X	X	X	
30			X	X	X	
31			X	X	X	
32			X	X	X	
33			X	X	X	
34			X	X	X	
35			X	X	X	
36			X	X	X	
37			X	X	X	
38			X	X	X	
39			X	X	X	
40			X	X	X	
41			X	X	X	
42			X	X	X	
43			X	X	X	
44			X	X	X	
45			X	X	X	
46			X	X	X	
47	X	X	X			
48			X	X	X	

Pen. #	TOFD UT	0° UT	ID ECT	OD ECT	J-Weld ECT	WOL PT
49	X	X	X			
50	X	X	X			X
51	X	X	X			X
52	X	X	X			X
53	X	X	X			X
54			X	X	X	
55			X	X	X	
56			X	X	X	
57			X	X	X	
58			X	X	X	
59			X	X	X	
60			X	X	X	
61			X	X	X	
62			X	X	X	
63			X	X	X	
64			X	X	X	
65			X	X	X	
HV			X		X	

BVPS 1R16 RPV Head Inspections

Examinations Completed - Penetration Map